

Northern Goshawk Survey on the Kanuti River, 2011

Kanuti National Wildlife Refuge

Tim Craig and Mike Spindler

Kanuti National Wildlife Refuge
U. S. Fish and Wildlife Service



Introduction

The northern goshawk (*Accipiter gentilis*) is the largest accipiter in North America. Its nesting range in North America, as well as in Alaska, is congruent with the tree line (Squires and Reynolds 1997), although there have been instances when goshawks have nested further north (Swem and Adams 1992). Goshawks utilize a variety of habitats for foraging and so are considered a habitat generalist at the landscape scale. However, although their home ranges may encompass a mosaic of open habitats with scattered forest patches, they usually nest in stands of large, mature trees that have a closed canopy (60% or greater canopy cover) and an open understory (Squires and Reynolds 1997). Even so, these nesting stands are often small (10–100 ha). In one study in interior Alaska, paper birch (*Betula papyrifera*) was the dominant tree in goshawk nesting stands and was also preferred as the actual nest tree over other species in the stand (McGowan 1975). In addition to selecting timber stands with old-growth characteristics, it has been noticed that goshawks often select nest sites that are near water (Squires and Reynolds 1997).

Goshawks show year-to-year fidelity to nest sites. However, as pointed out by McGowan (1975), prey availability strongly affects occupancy in interior Alaska (McGowan 1975). In particular, changes in northern goshawk nesting densities in the far north have been linked to snowshoe hare (*Lepus americanus*) numbers, a species whose populations fluctuate dramatically (Doyle and Smith 1994). Nonetheless, northern latitude populations may occur at lower

densities than those of populations that nest at lower latitudes in North America (Squires and Reynolds 1997).

Goshawks generally select prey that are 250–450 g in mass. On Kanuti NWR the following mammals in this size range are potential prey for goshawks: red squirrel (*Tamiasciurus hudsonicus*), northern flying squirrel (*Glaucomys sabrinus*), and snowshoe hare. Potential avian prey include: spruce grouse (*Falci pennis canadensis*), gray jay (*Perisoreus canadensis*), black-backed woodpecker (*Picoides arcticus*), American three-toed woodpecker (*P. tridactylus*), northern flicker (*Colaptes auratus*), various waterfowl species, and passerines like American robin (*Turdus migratorius*).

Some goshawks occur year around near the nearby Dalton Highway when snowshoe hares are numerous (pers. obs.), and this may be true for goshawk on the Kanuti NWR, as well. However, it is probable that birds migrate from the area during most winters, and probably do not return until March or April.

There is concern that some populations of goshawks in North America may be declining (Silver et al. 1991). In fact there have been petitions to list both the Queen Charlotte goshawk (*A. g. laingi*) in southeast Alaska and goshawks in the southwest (*A. g. atricapillus*) under the Endangered Species Act; in both cases this was considered because of changes, or proposed changes, in nesting habitat due to land management practices (i.e., timber harvest). The northern goshawk is protected under the Migratory Bird Treaty Act and Executive Order 13186 of 2001 indicated that Federal agencies have a responsibility to inventory and monitor migratory birds.

The Kanuti National Wildlife Refuge (NWR) is de facto wilderness where natural ecological processes prevail. There is no evidence that northern goshawk populations on or around the Refuge have been affected by anthropogenic activities, and no habitat changes caused by direct human activity are expected there in the future. However, models of vegetation change for interior Alaska indicate that by 2100 boreal habitat may decline greatly, and be replaced by Montane Cordillera and Boreal Transition habitat, biomes currently found in southern British Columbia and south-central Alaska, respectively (Murphy et al. 2010). These changes in vegetation will undoubtedly affect goshawk habitat and may change nesting density on Kanuti NWR, as well.

We propose to monitor nesting goshawks on Kanuti NWR for several reasons:

- The Refuge is located on the Arctic Circle. We are not aware of any nesting surveys of northern goshawks at, or even near, the northern extremity of their nesting range in North America.
- As the climate warms, vegetation changes in the region are expected to be extensive. The associated changes in habitat for goshawks are likely to be commensurately dramatic. The management strategy for the Kanuti NWR will ensure that the Refuge will retain its wilderness character into the future. Therefore, the Refuge is an ideal

location to monitor goshawk populations in the absence of anthropogenic disturbances, particularly as they relate to climate change.

- Fire is the dominate process driving habitat changes in interior Alaska, including on Kanuti NWR; over 1.2 million acres have burned on the Refuge since 1950 (USFWS 2008). As a result, nesting habitat for northern goshawks on the Refuge is in constant flux. Squires and Reynolds (1997) have pointed out that researchers do not know how goshawk populations are affected by increased habitat fragmentation and changes in habitat structure at different landscape scales.

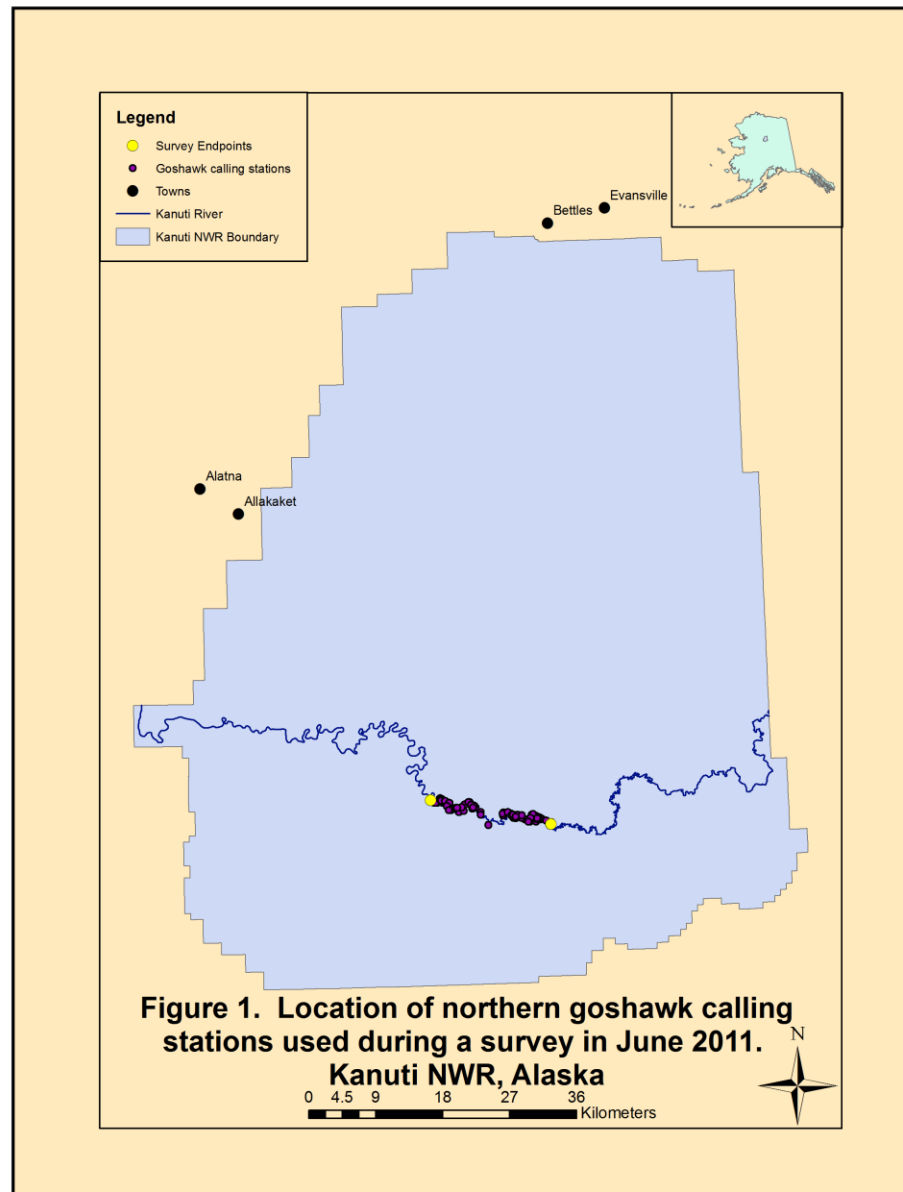
Goshawks are secretive during incubation. However, they vigorously defend their nest sites beginning when their young hatch, and an alarm call is an important feature of this defense. Later, as nestlings approach fledging, nesting adults respond to the hunger calls of their young. Attention to these calls continues even after fledging because young goshawks are dependent on their parents for a period immediately after they leave the nest. The most efficient method for locating goshawk nests involves broadcasting tape recordings of these two types of calls in goshawk nesting habitat (Kennedy and Stahlecker 1993, Joy et al. 1994). Specifically, the goshawk “alarm” call is used throughout the nestling period, while the “hunger-begging” call is broadcasted during the late nestling and fledgling period. The USDA Forest Service (USFS) developed a nesting survey protocol using these broadcasted goshawk vocalizations (Woodbridge and Hargis 2006). This technique was tested at known nest areas by experienced surveyors who found that when one survey was conducted along a transect line in a season, response rates were 90% at active nests and 64% at occupied territories (i.e., where nests had failed or non-breeders were present). In contrast, when two surveys were conducted along transects during the same nesting season, 94 percent of the active territories and 87 percent of occupied unsuccessful territories were detected.

The purpose of our study was to develop a method to monitor nesting northern goshawks on Kanuti NWR using broadcast calls. Because Kanuti NWR has no roads, and the terrain is not amenable to walking, the common practice of calling along transects either on foot or from wheeled vehicles is not an option. However, there are several rivers on the Refuge that are “floatable” and provide passage though the landscape via boats. These rivers also promote the growth of large, older trees, principally white spruce (*Picea glauca*) and paper birch (*Betula papyrifera*) in places, and thus, goshawk nesting habitat. Even so, appropriate goshawk nesting habitat is spotty along rivers on the Refuge because fires have changed adjacent habitats. We used the USFS protocol for surveying northern goshawks in summer 2011 with the modification that we broadcasted calls from stations along Kanuti River and traveled down this “transect” line via boat. We acknowledge that this constituted “convenience sampling” and that such surveys do not result in an “inventoried area” (Woodbridge and Hargis 2006). This is particularly true in regard to goshawks on Kanuti NWR where there are stands of large trees located away from rivers. However, the economic and physical constraints of working in this comparatively untrammelled and challenging environment dictated how surveys can be conducted.

Study Area

Within the Refuge, we selected the Kanuti River, downstream (west) of Kanuti Cabin (N 66.17932° x W 151.73831°), as a location to develop, and test, survey techniques for northern goshawks (Fig. 1). We chose this section of river for several reasons:

- There is a boat suitable for traveling down, and back upstream, permanently available at the Kanuti River near Kanuti Cabin.
- Storage space, fuel and a float-plane accessible lake are located at the cabin.
- The river is consistently deep enough year-to-year during goshawk nesting season to float downstream and return to the cabin via jet boat.
- There are portions of the river that are within “USFS protocol” distance of appropriate northern goshawk nesting habitat.
- By initiating the calling transect at the upstream end of a river transect, we increased the amount of time in which we could detect goshawks because we were able to float quietly between calling stations.
- Kanuit Cabin is a center of activity for FWS personnel, annually.

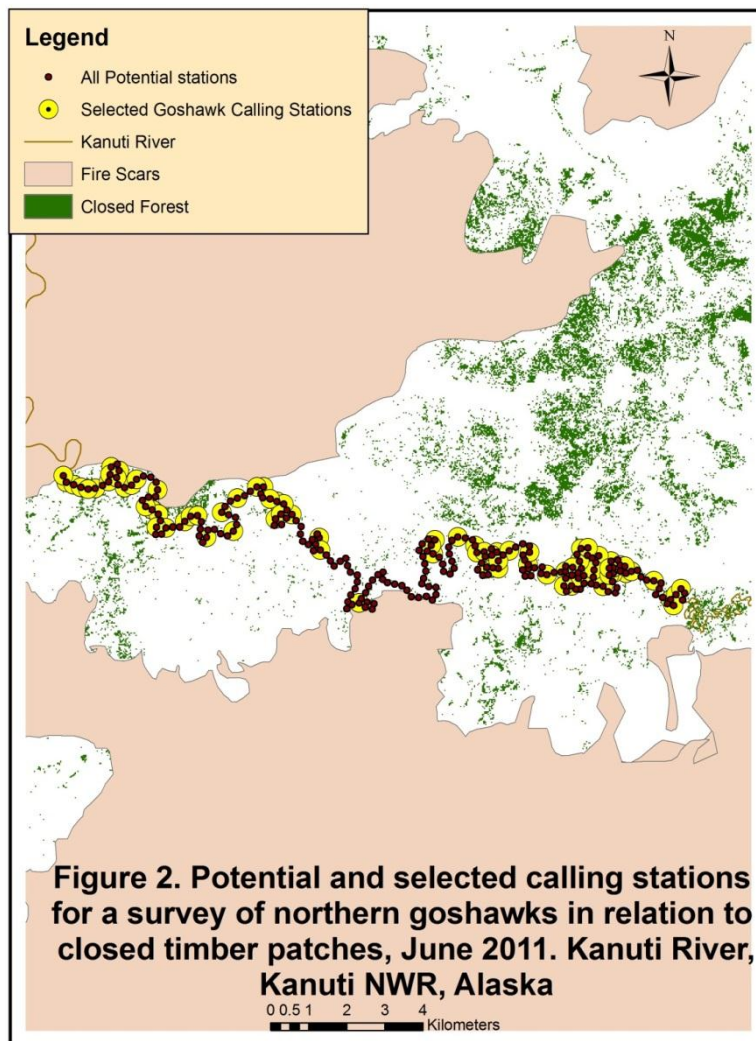


Methods

Establishing calling stations: The USFS protocol requires calling stations to be positioned along transects so that they are ≤ 200 m apart. Because the Kanuti River is sinuous, we used GIS environmental layers and ArcMap 9.3 to determine all of the potential calling station locations along the river downstream of Kanuti Cabin that met this criterion (Appendix 1.). Because goshawks generally nest in “closed” forest stands of large trees, not all of these potential calling stations were within 200 m of appropriate goshawk nesting habitat, another requirement of the protocol. We reviewed the descriptions of Earthcover classes for the Refuge (USDOI/BLM et al. 2002), and determined that “Closed Needleleaf,” “Closed Deciduous,” and “Closed Mixed Needleleaf/Deciduous” patches best match goshawk nesting habitat. We then reviewed burned area perimeter maps to establish where fires had occurred along the Kanuti River after 1999 when the Earthcover imagery used for the area was acquired. In summary, we identified the calling stations we planned to use by overlaying maps of potential calling stations, vegetation classes and recently burned areas (Appendix 2.). Specifically, we:

- “Clipped” a polyline segment of the Kanuti River with a polygon of the Kanuti NWR boundary;
- Added a field (length) in the attribute table for the shapefile of the river;
- “Calculated Geometry” in meters for the entire length of the river;
- Placed calling stations every 200 m along the river using the “Create Routes Tool;”
- Added XY coordinates in decimal degrees to each of the calling stations;
- Used the “Buffer Tool” to create a dissolved 100 m buffer around each calling station to ensure each was 200 m apart;
- Overlaid the calling stations and their buffers with a current Fire History Layer for the Kanuti NWR (Kanuti NWR files);
- Selected only those calling stations that lay downstream of the Kanuti Cabin and that did not fall within areas identified as having burned;
- Overlaid the calling stations with a vegetation layer for the Kanuti NWR (USDI/BLM et al. 2002) and selected only those stations containing, or within the specified distance of, appropriate goshawk nesting habitat (“Closed Needleleaf,” “Closed Deciduous,” and “Closed Mixed Needleleaf/Deciduous” Classes) that were about 10–30 ha (min. of 10 pixels). In some cases where groups of pixels were separated by in a narrow strip of appropriate habitat we included them, as well.

The above procedure produced 80 calling stations along Kanuti River between Kanuti Cabin and its confluence with the Koyukuk River that were likely to be near “closed” forest patches that had not burned since the Earthcover maps were produced (Fig. 2).



We appended the suffix “G” after the station numbers for each of these 80 stations and then uploaded them into a GPSMap 76CSX Unit. There is acknowledged error in Earthcover maps (USDI/BLM 2002) and the perimeters displayed on burned area maps contain a mosaic of burned and unburned inclusions (USGS 2010). Therefore, in addition to the selected calling stations, we uploaded the locations of all other potential calling stations in the GPS in case *in situ* inspection revealed that unselected calling stations were in appropriate nesting habitat, too.

Methods of translocation to/from the beginning of the survey transect: We flew to Kanuti Lake on 10 June 2011 in a Bellanca Scout float-plane. We unloaded the plane, transported our gear to the nearby river and reloaded it in an aluminum boat equipped with a 30 hp jet unit. Two people conducted the survey and both acted as observers, but one person had a primary responsibility of operating the boat, and the other conducting calling operations. We launched the boat on the

Kanuti River that day at 16:37 (ADT), floated to the first calling station, and started calling at 16:40. We continued downstream for the next several days calling at stations and traveling between stations in the boat. When we finished the survey on 12 June, we traveled back upstream to the Kanuti Cabin under power, reloaded our gear into the plane, and flew to Bettles, Alaska. We returned to Fairbanks from Bettles via commercial carrier.

Methods of translocation between calling stations: We used the motorized skiff to float at river current speed between adjacent calling stations. This time of quiet floating allowed us to continue to listen and look for responding birds after calling at a station and before arriving at the next. Current speed varied but was generally < 3 km/hr. Observers remained alert and quiet at calling stations, and when floating between stations. We did not use the motor to decrease travel time between adjacent call stations since the time spent floating between stations is part of the survey. However, when calling stations were isolated (i.e., more than 200 m apart), we traveled under power between stations, but shut down the motor and floated up to, and away from, the next calling station in order to replicate a time of quiet floating around stations.

Methods at each calling station:

We used a FoxPro NX3 broadcasting caller at near maximum volume (the device is capable of broadcasting at 100 dBs) during each calling session. The calls we used were preprogrammed into the unit by FoxPro, Inc. and advertised as the “Government Program.” It was determined in the only published goshawk study conducted in interior Alaska that hatching generally occurs during late May (McGowan 1975). Because Kanuti NWR is 2 degrees of latitude north of this study area, we speculated that hatching on the Refuge would be during the first week of June and that fledging probably occurs around the second or third week of July. Based on these assumptions, we choose to conduct our survey beginning on 10 June 2011 and to broadcast the goshawk “alarm” call from calling stations.

The USFS guidelines state that calling should begin no earlier than a half hour before sunrise and should cease by a half hour before sunset (Woodbridge and Hargis 2006). However, because there is continuous daylight during the goshawk nesting period on Kanuti NWR, this criterion does not apply. During our survey, we initiated calling no earlier than 08:23 and stopped calling by 20:50 (ADT).

At each calling station, we broadcasted the appropriate call starting at about 60 degrees from the general direction the river was flowing. Each calling episode lasted about 10 seconds, followed by a 30 second period of silence when we listened, watched for respondents, and rotated the calling device 120 degrees. We repeated this sequence two more times, rotating 120 degrees from the last broadcast after each calling episode. We repeated this three-call sequence two times at each station (ergo, a total of 60 seconds of calling time, and 240 seconds of listening time per station, divided into 6 episodes), and then floated to the next station.

- Calling was usually conducted from the boat at anchor in mid-stream. If current strength was too great to allow this, we put the boat ashore and called from that location.
- Surveys were conducted when there was little rain and wind was less than 24 km/hr.
- Station number, weather, date and time of the calling session were recorded at each calling station regardless of results.

When a goshawk was detected, we recorded:

- Time of detection;
- Detection type (silent approach, vocal approach, vocal response with no approach, etc.);
- Compass bearing to the respondent, or if a visual record, the direction the goshawk was moving in;
- Sex and age of the goshawk (adult/ juvenile/fledgling) if known.

When we finished calling at established goshawk calling stations we continued downstream to Kanuti Chalatna Creek, then up that creek a short way, calling opportunistically wherever there appeared to be appropriate goshawk habitat. The principal purpose of the survey was to detect goshawks. However, we recorded other animals which responded to our goshawk calls, as well as incidental wildlife sightings that we made during calling sessions, and while traveling along the river. While the list of species we recorded during incidental observations is accurate, the number of individuals we noted is not because: a) we made no attempt to discriminate between individual singing passerines at calling stations, b) we estimated flock sizes, and c) we recorded each raptor nest that we encountered as “1” observation. Similarly, to expedite the survey, we did not attempt to record the exact locations of individuals we encountered while traveling between sites. Instead, we accredited observations to the approximate mid-point between the sites we were traveling between.

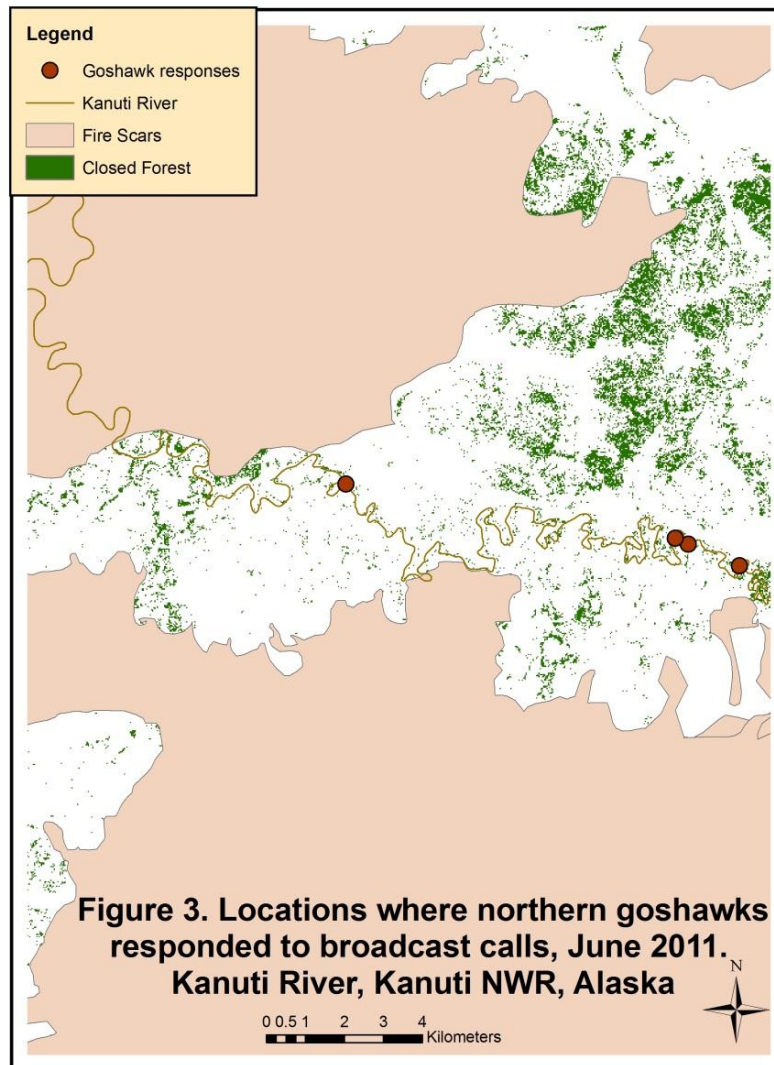
Results

Observations:

We elicited responses from northern goshawks at 4 of 80 calling stations (Fig. 3). At three of these locations we only heard faint, vocal responses from goshawks, apparently from a great distance away (Table 1.). At the other station, an adult male goshawk flew by silently about 50 m upstream of our boat.

Table 1. Responses of northern goshawks at 4 different calling stations in June 2011. Kanuti River, Kanuti National Wildlife Refuge, Alaska.

Station number	Latitude	Longitude	Behavior	Azimuth to response	Time
004G	66.18134	-151.74027	Faint vocal response	19°	16:55
017G	66.18671	-151.76892	Faint vocal response	330°	17:55
021G	66.18815	-151.77615	Faint vocal response	60°	18:46
165G	66.20309	-151.96189	Male flew silently by	190° (direction flown)	14:20

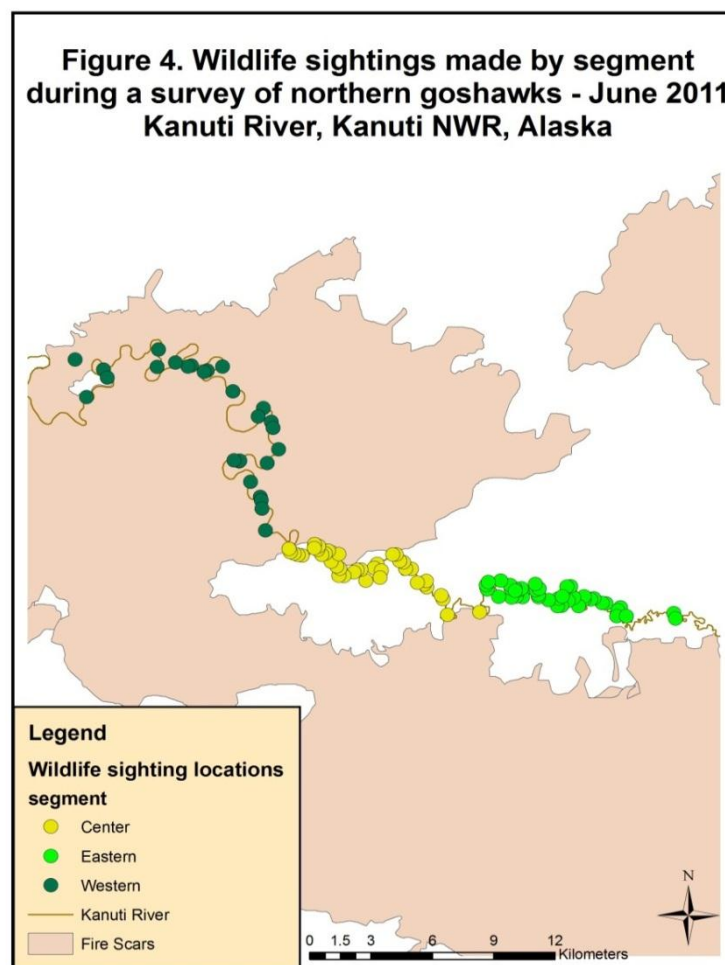


Five other wildlife species respond to our calls during the survey (Table 2). Most of these other respondents were birds, and most flew toward us emitting their own alarm calls. Gray jays and American robins were the most frequent respondents and gray jays frequently mimicked goshawk alarm calls, which required discrimination on our part to avoid confusion with actual goshawks.

Table 2. Responses detected at northern goshawk calling stations in June 2011. Kanuti River, Kanuti National Wildlife Refuge, Alaska

Species	Northern Goshawks	Rusty Blackbird	Gray Jay	American Robin	Northern Harrier	Red Squirrel
Number of stations	4	5	27	17	1	5

In all we detected about a third of the bird species recorded to occur on Kanuti NWR during our 3-day goshawk survey of the Kanuti River and lower Kanuti Chalatna Creek (Table 3). To simplify discussion of these wildlife sightings, we have divided the surveyed area into 3 segments (Fig. 4). The westernmost segment of the survey area included the section of Kanuti River downstream of the last identified northern goshawk calling station to the mouth of Kanuti Chalatna Creek, and along with the lower portion of Kanuti Chalatna Creek, itself. The center segment of the survey area began about 32 km downstream of the Kanuti Cabin and ended further downstream at the last established goshawk station. The easternmost segment included the section of river upstream of the center segment of the surveyed area to Kanuti Cabin, plus a short stretch of river above the cabin that we covered after we had completed the rest of the survey. We recorded all wildlife sightings we made in the short stretch of river upstream of Kanuti Cabin but we did not play pre-recorded northern goshawks there.



The western segment of the survey area was the longest stretch of river we surveyed. Nonetheless, we spent less time there because there is very little northern goshawk nesting habitat adjacent to the river in this segment due to recent fires (ca. 2005). We detected no northern goshawks in this survey segment, and in fact, we only called at 6 locations in this stretch of river. However, we found more broods, nests and colonies of other birds in this area than in the other segments we surveyed. Of particular interest, we found more nests of other raptors in this segment of river (5) than in the others.

The only goshawk that responded to our calls by actually flying in to us was in the center segment of the surveyed river. This bird simply flew by silently, a behavior that suggests that while we probably were within a nesting territory, the actual nest site was probably not nearby. We found the greatest diversity of other wildlife species (32) in this segment, but recorded the fewest number of individual detections, particularly of geese.

We detected more northern goshawks (3) in the eastern segment of river than in the rest of the survey area. However, all of these detections were auditory detections, and two were very faint, as though the respondents were a long way from our calling stations. Even though we detected the fewest number of other bird species in the eastern segment of the survey area, we made the most individual sightings there, mainly because greater white-fronted geese were more abundant in this segment of river.

Table 3. Species of birds and mammals detected in three river segments during a northern goshawk survey of a portion of the Kanuti River, June 2011. Kanuti National Wildlife Refuge, Alaska.

Species	Number detected (number broods ¹ , nests ² or colonies ³)			Total observations (number broods ¹ , nests ² or colonies ³)
	Eastern Segment [38 km*]	Center Segment [21 km]	Western Segment [59 km]	
Greater white-fronted goose ¹	85	6 (1)	20(2)	111 (3)
Canada goose ¹		2	7 (1)	9 (1)
Trumpeter swan		7	1	8
Unid. duck		1		1
American wigeon	14	18	9	41
Mallard	8	2		10
Northern shoveler	1			1
Green-winged teal	4		3	7
Unid. scaup	6	1	2	9
Bufflehead			1	1

Unid. merganser			4	4
Common merganser		1		1
Red-throated loon			1	1
Unid. loon		1	2	3
Osprey²			(1)	(1)
Bald eagle²	2		1(1)	3(1)
Sharp-shinned hawk			1	1
Northern goshawk	3	1		4
“Harlan’s” red-tailed hawk²		(1)	7 (3)	7 (4)
Golden eagle			1	1
Peregrine falcon²	1	(1)	1	2(1)
Sandhill crane		5		5
Unid. sandpiper			3	3
Spotted sandpiper	1	3	3	7
Lesser yellowlegs		1		1
Least sandpiper	2			2
Wilson’s snipe		1	1	2
Mew gull		1	1	2
Unid. owl			1	1
Great horned owl			1	1
Northern hawk owl	1		1	2
Great gray owl	1		2	3
Belted kingfisher		3	1	4
Northern flicker		1		1
Olive-sided flycatcher	1	1		2
Western wood-pewee		2		2
Alder flycatcher		2		2
Hammond’s		1		1

flycatcher				
Gray jay		1		1
Common raven		1		1
Tree swallow		2	3	5
Bank swallow³			(1)	(1)
Ruby-crowned kinglet	1			1
Swainson's thrush	1	1		2
American Robin	1			1
Bohemian waxwing	6			6
Orange-crowned warbler	1			1
Yellow warbler		1		1
Fox sparrow		1		1
White-crowned sparrow	1			1
Golden-crowned sparrow	1			1
Dark-eyed junco		1		1
Rusty blackbird	2			2
White-winged crossbill	1			1
Beaver	7	2		9
Moose		1	3	3
Total species	23	32	27	56
Total observations	151	72 (3)	81 (9)	304 (12)
Approximate time spent per segment	10:40*	8:20	6:50	25:50
(* includes approximate 10 km trip upstream of Kanuti Cabin made after the formal survey was complete.				

Cost:

We flew from Fairbanks to Kanuti Cabin in the government-owned Bellanca Scout then used an aluminum boat with a 40 hp outboard (Yamaha) equipped with a jet unit (30 hp delivered with the jet) to conduct the survey. We used 3.5 gal of fuel while traveling downstream conducting the survey. In contrast, we used 9 gal to return to the Kanuti Cabin. We estimated fuel

consumption to be about 1 gal of fuel/45 min. during our upstream travel (26 km/hr at about ¾ throttle).

Table 4. Expenses of conducting a northern goshawk survey along a portion of the Kanuti River, June 2011. Kanuti National Wildlife Refuge, Alaska.

Person hours¹	Aircraft hours¹	Aircraft hourly¹ costs	Aircraft fuel¹	Food	Boat fuel	Commercial airfare²	Misc.³	Total cost
66	4.7	\$587.50	37.6 gal. @ \$8.00 = \$300.8	\$175.00	12.5 gal. @ \$11.00/gal. = \$137.50	\$390.40	\$210.00	\$1801.20

¹ Includes flight via GOV plane to Kanuti Cabin from Fairbanks/return to Bettles, Alaska.

² One way, 2 people from Bettles to Fairbanks with gear.

³ Foxpro caller, batteries, white gas, etc.

Discussion

There is little information on goshawk nesting density in interior Alaska; none of it was collected near the Arctic Circle, or along rivers. McGowan (1975) found that the density of goshawks in the vicinity of Fairbanks, Alaska ranged from one nest per 46 to 55 km² and that this density was dependent on prey populations, a common observation elsewhere (Squires and Reynolds 1997). The linear nature of our transect line did not lend itself to a direct comparison with these data. However, if we assume that goshawks that nested within 200 m of our stations responded to our broadcasted calls, and none that nested beyond this distance did, the density of birds along this section of Kanuti River was 1 nest per 0.6 km². This apparently high density probably can be explained in one of two ways: either goshawks are responding at much greater distances than 200 m from calling stations, or the frequent fires on the Kanuti NWR have concentrated birds into the few remaining stands of older trees in the area. Further study is required to determine which explanation is more likely.

Our experience with nesting goshawks in Alaska, and elsewhere, has been that when adults have young in the nest, they are very aggressive. The low intensity of defensive behavior by responding adults that we observed in 2011 (3 auditory responses and, one silent fly-by) suggests that we may have been too early in the nesting season to elicit full defensive responses by adults.

Management Implications:

Our results indicate that establishing calling stations along floatable rivers where there is appropriate habitat is an efficient and inexpensive method to monitor nesting goshawks in remote portions of interior Alaska, like Kanuti NWR.

Recommendations:

- A systematic survey for nesting goshawks should be continued along the Kanuti River and a second survey should be initiated along another river on Kanuti NWR, perhaps the South Fork Koyukuk or Jim River. The lengths of the surveys should not exceed 3 days.

However, to improve accuracy, each survey should be repeated after a day's delay so that each survey is conducted two times in one 7-day period.

- Goshawk surveys should be repeated on a biennial basis and surveys of the two rivers should be conducted on alternating years.
- Until enough phenological data are collected to determine optimum survey dates, surveys on Kanuti NWR should be initiated no earlier than the third week in June, and no later than the second week in July.
- An attempt should be made to locate nests of responding birds to determine the distance at which birds respond to broadcast calls on Kanuti NWR and define nesting habitat preferences for goshawks on the Refuge.
- Nesting attempts and the subsequent success of nesting northern goshawks is known to be linked to prey availability (Squires and Reynolds 1997). We do not currently measure the relative density of any potential prey species on the Refuge. However, in the absence of information on prey availability, responses by nesting goshawks along survey routes are difficult to interpret. Snowshoe hares are probably a major prey of goshawks on the Refuge. Hare pellet transects (Collins et al. 2004) should be conducted on each surveyed river, concurrent with goshawk surveys. Selected goshawk calling stations should be used as beginning points for pellet transects.
- We suggest that the Alaska Landbird Monitoring Survey Protocol for initiating station calling (i.e. after 03:00) be adopted for future goshawk surveys on Kanuti NWR (<http://alaska.usgs.gov/science/biology/bpif/monitor/alms.php#information>). We further suggest that calling cease each day before 22:00.

Literature Cited

Collins, G. H., H. K. Timm, and W. N. Johnson. 2004. Snowshoe hare pellet counts. Progress Report No. 04-04. Tetlin National Wildlife Refuge, U. S. Fish and Wildlife Service, Tok, Alaska. 17 p.

Doyle, F. I. and J. N.M. Smith. 1994. Population responses of Northern Goshawks to the 10-year cycle in numbers of snowshoe hares. In: *The Northern Goshawk : ecology and management*. p. 122-129. W.M. Block, M.L. Morrison, and M.H. Reiser. *Eds.* Cooper Ornithological Society; Studies in Avian Biology, no. 16.

Joy, S.M.; Reynolds, R.T.; Leslie, D.G. 1994. Northern goshawk broadcast surveys: hawk response variables and survey cost. *Studies in Avian Biology*. 16: 24-30.

Kennedy, P. L. and D. W. Stahlecker. 1993. Responsiveness of nesting northern goshawks to taped broadcasts of three conspecific calls. *Journal of Wildlife Management* 57:249-257

McGowan, J. D. 1975. Distribution, density and productivity of goshawks in interior Alaska. Proj. Rep. W-17-4, W17-5, W-17-6, Job 10.6A. Fed. Aid Wildl. Restor. Alaska Dep. of Fish and Game. 30 pp. and appendices.

Murphy, K., F. Huettmann, N. Fresco and J. Morton. 2010. Connecting Alaska landscapes into the future. SNAP [Scenarios Network for Alaska Planning], University of Alaska, School of Natural Resources and Agriculture Sciences. <http://www.snap.uaf.edu/downloads/connecting-alaska-landscapes-future>

Silver, R.D.; Galvin, P.; Hirsch, S.; Hitt, S.M.; Hoffman, S.W.; MacFarlane, A.; Sandell, C.I.; Sauber, M.; Schulke, T.; Wardwell, G.; Wotkyns, S. 1991. Letter to the Department of Interior petitioning to list the northern goshawk (*Accipiter gentilis*) in Utah, Colorado, New Mexico, and Arizona under the Endangered Species Act. Phoenix, AZ: Maricopa Audubon Society. 61 p.

Squires, John R. and Richard T. Reynolds. 1997. Northern Goshawk (*Accipiter gentilis*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online:
<http://bna.birds.cornell.edu/bna/species/298doi:10.2173/bna.298>

Swem, T. and M. Adams. 1992. A northern goshawk nest in the tundra biome. Journal of Raptor Research 26:102.

USDOI/BLM, USDI/USFWS, and Ducks Unlimited, Inc. 2002. Kanuti /Ray Mountains/Hogatza River earth cover classification. BLM-Alaska Technical Report 28. BLM/AK/ST-02/009+6500+931. Anchorage, AK. 85 pp.

USFWS. 2008. Revised Comprehensive Conservation Plan Kanuti National Wildlife Refuge. U. S. Fish and Wildlife Service, Fairbanks, Alaska. 217 pp.

USGS. 2010. Wildland Fire Decision Support System.
http://wfdss.usgs.gov/wfdss/WFDSS_Home.shtml

Woodbridge, B. and C. D. Hargis, C.D. 2006. Northern goshawk inventory and monitoring technical guide. Gen. Tech. Rep. WO-71. Washington, DC: U.S. Department of Agriculture, Forest Service. 80 p.

Appendix 1.

Potential northern goshawk calling stations along a section of Kanuti River, Alaska

STATION	POINT_X	POINT_Y
1	-151.77729277600	66.18969570730
2	-151.76891517400	66.18670676430
3	-151.79333481900	66.18647419090
4	-151.76009217000	66.18578220440
5	-152.09229817900	66.21230462830
6	-152.04732008200	66.21323034110
7	-152.04070866000	66.20826999190
8	-152.04281653700	66.20526598030
9	-152.04128972600	66.19940588230
10	-152.02724475200	66.20099035840
11	-152.01449076300	66.20202154680
12	-152.01169929200	66.19835393650
13	-151.99843563000	66.20353150130
14	-151.99308234400	66.20732231240
15	-151.74871499000	66.18416428900
16	-151.97776677300	66.20982927210
17	-151.97034449400	66.20628317060
18	-151.97138879700	66.20217924310
19	-151.96188759400	66.20309411390
20	-151.95610691400	66.19672868180
21	-151.94620431700	66.19743972350
22	-151.94261034600	66.19331604860
23	-151.78437159400	66.19103850170
24	-151.93138550500	66.19236598000
25	-151.92494844700	66.18678022710
26	-151.93159086900	66.18046626570
27	-151.91677179200	66.18022996950
28	-151.90985241400	66.18885641880
29	-151.89911474500	66.18555913410
30	-151.88353527500	66.18513275420
31	-151.88293082000	66.19629149840
32	-151.88054460900	66.19280793880
33	-151.87095931400	66.18793817490
34	-151.87128796500	66.19424773730
35	-151.74816052700	66.18067661050
36	-151.85726007000	66.19580889570
37	-151.85245240600	66.19022257330
38	-152.07551228900	66.21064828090
39	-152.06603958500	66.21559956260
40	-152.06235874700	66.21134030290
41	-151.82556090000	66.18851678110
42	-151.99955126900	66.19849811240
43	-151.78635302600	66.18411883840
44	-151.74345853600	66.18016913790

45	-151.92025685900	66.18411579950
46	-151.88528218800	66.18277008270
47	-151.88558025200	66.19055072330
48	-151.84656086000	66.19350227590
49	-151.76560329600	66.18713614400
50	-151.84961431800	66.18922106610
51	-151.75687280300	66.18498117470
52	-151.79464372900	66.18815954050
53	-151.81806605300	66.18730600910
54	-151.79436467700	66.19289317400
55	-151.74977835000	66.18283211850
56	-151.78608599400	66.18944310430
57	-151.77541217200	66.18218038310
58	-151.77616801500	66.18684559840
59	-151.74554436300	66.17924519380
60	-151.80659106900	66.18752345870
61	-152.08819717000	66.21167444900
62	-152.07141494200	66.21131163960
63	-152.06242875700	66.21626610180
64	-152.05846579000	66.21061459310
65	-152.04307457900	66.21293113630
66	-151.82171490500	66.18870607950
67	-152.04487825100	66.20826750290
68	-152.03943856700	66.20414532330
69	-151.78737451500	66.18772459350
70	-152.03775662800	66.19944511430
71	-152.02422313300	66.20230492970
72	-152.01516193600	66.20037325860
73	-152.01069999200	66.20005601870
74	-151.99617064800	66.19964372380
75	-152.00244097300	66.20410281890
76	-151.98900954000	66.20788308390
77	-151.97951087100	66.20825731340
78	-151.96632090800	66.20568350160
79	-151.97209190900	66.20071316170
80	-151.95945452000	66.20161078130
81	-151.95271741400	66.19586486540
82	-151.94848402700	66.19594052490
83	-151.94020417600	66.19188473370
84	-151.77317353600	66.18990633990
85	-151.93044430500	66.19066587590
86	-151.92639110800	66.18509194530
87	-151.92859831400	66.18149679710
88	-151.91575516300	66.18147654720
89	-151.91845676200	66.18564292010
90	-151.91027058100	66.18714307680
91	-151.89622937200	66.18436713300
92	-151.88172522600	66.18191484850
93	-151.88748674200	66.18586308040
94	-151.80375887200	66.18291569880

95	-151.88635598400	66.19227959540
96	-151.87913230100	66.19609261180
97	-151.87696661700	66.19193867610
98	-151.86841950900	66.18922656650
99	-151.86921510000	66.19583255860
100	-151.85590879400	66.19439816070
101	-151.84345319700	66.19271265790
102	-151.85476518500	66.18875730200
103	-151.78227696300	66.18388105370
104	-151.74026525600	66.18133689580
105	-151.82836369500	66.19185000820
106	-151.79670664700	66.18719803790
107	-151.83995172500	66.19200712460
108	-151.73509216100	66.18159391060
109	-151.82825403400	66.19447126940
110	-151.82870652200	66.18829719980
111	-151.76200024000	66.18734307570
112	-151.84608582300	66.18906642420
113	-151.80395522900	66.18762780070
114	-151.75275111800	66.18473546630
115	-151.79548688400	66.18989488060
116	-151.81479565700	66.18704271570
117	-152.08409182800	66.21102345460
118	-152.04003213800	66.21166975060
119	-152.04834034200	66.20752923650
120	-152.03826639400	66.20256349450
121	-151.78779533000	66.18601377980
122	-152.03516224000	66.20089006140
123	-151.79037842400	66.19298061090
124	-152.02068982200	66.20337839210
125	-152.01604122300	66.19875173070
126	-152.00699517200	66.20019896450
127	-152.00040002800	66.20551088310
128	-151.98537924000	66.20891349880
129	-151.75191228300	66.18146181320
130	-151.97837078900	66.20725504880
131	-151.96448801100	66.20416351880
132	-151.96800694700	66.20091569350
133	-151.95670112800	66.20020766760
134	-151.95035159500	66.19707487980
135	-151.94989703800	66.19438102890
136	-151.93807217500	66.19068778390
137	-151.77199080800	66.18866915980
138	-151.92876262500	66.18905978580
139	-151.92903425900	66.18368915390
140	-151.77441304300	66.18340318070
141	-151.92438837100	66.18177189530
142	-151.91974271000	66.18190784730
143	-151.77212065100	66.18733204240
144	-151.90757940000	66.18635332480

145	-151.89390697500	66.18286673020
146	-151.88648806200	66.18714025710
147	-151.80069841400	66.18421448290
148	-151.88142355700	66.19484643290
149	-151.87522125800	66.19032579050
150	-151.86969748100	66.19091964170
151	-151.86579403300	66.19663481900
152	-151.74180589500	66.17875755260
153	-151.85495315600	66.19275046130
154	-151.85205465900	66.18743727400
155	-151.80362760700	66.18885131120
156	-152.06763200600	66.21217227650
157	-152.06132468000	66.21471947230
158	-152.05445733700	66.21122337810
159	-151.81741608600	66.18884204480
160	-151.99397021200	66.20114402700
161	-151.77955907700	66.18248243440
162	-151.73714176700	66.18259458590
163	-151.91606975100	66.18708526380
164	-151.87946097200	66.18315024830
165	-151.88851893000	66.19373241050
166	-151.79645672300	66.18589687010
167	-151.84635654900	66.19204775640
168	-151.82428930800	66.19390279190
169	-151.82733181000	66.18684599310
170	-151.77859618600	66.18646812550
171	-151.84279914300	66.18885403360
172	-151.79564692500	66.18332771490
173	-151.80392465800	66.18598080880
174	-151.82739921200	66.19063343280
175	-151.83616209100	66.19291290520
176	-151.79682095400	66.19159133940
177	-151.73645258900	66.17999651320
178	-151.81058858900	66.18749048040
179	-151.79077729000	66.19122089110
180	-151.77675384100	66.18486327410
181	-151.76927453400	66.18840931980
182	-151.79973131300	66.18851082380
183	-152.09384435700	66.21387552470
184	-152.07992700100	66.21057575640
185	-152.06662477600	66.21384260690
186	-152.06292073700	66.21305509320
187	-152.05132523000	66.21249398660
188	-152.03947579200	66.20992298540
189	-152.04655960600	66.20602747190
190	-152.04075976800	66.20108928430
191	-151.78923238200	66.18452952690
192	-152.03118236000	66.20106482890
193	-152.01666728200	66.20352503590
194	-152.01423690800	66.19715225740

195	-152.00354261100	66.19907890230
196	-151.99450082900	66.20282457470
197	-151.99717988500	66.20674066990
198	-151.98163424400	66.20986651650
199	-151.97433211500	66.20692389350
200	-151.96824747500	66.20327645470
201	-151.96518432900	66.20228157980
202	-151.95708526900	66.19843251030
203	-151.94757040800	66.19835829170
204	-151.94590729500	66.19451459500
205	-151.93459857900	66.19177144130
206	-151.77614893400	66.18815125310
207	-151.92476599400	66.18832524320
208	-151.93078175000	66.18208863370
209	-151.92078829300	66.18079537790
210	-151.92286319700	66.18276708340
211	-151.91290862700	66.18833301460
212	-151.90335295500	66.18595994850
213	-151.88964058500	66.18256974430
214	-151.87933410000	66.18483482580
215	-151.88508272300	66.18876746700
216	-151.79826104600	66.18339722190
217	-151.88649102500	66.19524999950
218	-151.88384089600	66.19352969500
219	-151.87467784600	66.18855453130
220	-151.87109299000	66.19260929240
221	-151.86148126700	66.19629573320
222	-151.85068343400	66.19289791260
223	-151.85024322700	66.19177403370
224	-151.84891771800	66.18748705910
225	-151.77846770500	66.18803789800
226	-151.82559144100	66.18957312910
227	-151.80032428000	66.18672347000
228	-151.83223958500	66.19374254990
229	-151.82439962200	66.19242033590
230	-151.82408334800	66.18687138800
231	-151.84260621400	66.19060176070
232	-151.79320307100	66.18470195330
233	-151.78814146300	66.19063626720
234	-151.80509327000	66.18426698810

Northern goshawk calling stations chosen for calling along Kanuti River, Alaska in 2011. Only stations that were within ≤ 200 m of appropriate nesting habitat were selected.

STATION	POINT_X	POINT_Y
1	-151.77729277600	66.18969570730
2	-151.76891517400	66.18670676430
3	-151.79333481900	66.18647419090
5	-152.09229817900	66.21230462830
8	-152.04281653700	66.20526598030
12	-152.01169929200	66.19835393650
14	-151.99308234400	66.20732231240
16	-151.97776677300	66.20982927210
17	-151.97034449400	66.20628317060
18	-151.97138879700	66.20217924310
19	-151.96188759400	66.20309411390
21	-151.94620431700	66.19743972350
23	-151.78437159400	66.19103850170
32	-151.88054460900	66.19280793880
38	-152.07551228900	66.21064828090
39	-152.06603958500	66.21559956260
44	-151.74345853600	66.18016913790
49	-151.76560329600	66.18713614400
50	-151.84961431800	66.18922106610
54	-151.79436467700	66.19289317400
58	-151.77616801500	66.18684559840
61	-152.08819717000	66.21167444900
64	-152.05846579000	66.21061459310
68	-152.03943856700	66.20414532330
69	-151.78737451500	66.18772459350
71	-152.02422313300	66.20230492970
74	-151.99617064800	66.19964372380
75	-152.00244097300	66.20410281890
78	-151.96632090800	66.20568350160
96	-151.87913230100	66.19609261180
100	-151.85590879400	66.19439816070
101	-151.84345319700	66.19271265790
103	-151.78227696300	66.18388105370
104	-151.74026525600	66.18133689580
112	-151.84608582300	66.18906642420
113	-151.80395522900	66.18762780070
114	-151.75275111800	66.18473546630
115	-151.79548688400	66.18989488060
116	-151.81479565700	66.18704271570
117	-152.08409182800	66.21102345460
122	-152.03516224000	66.20089006140
123	-151.79037842400	66.19298061090
124	-152.02068982200	66.20337839210
137	-151.77199080800	66.18866915980
141	-151.92438837100	66.18177189530
147	-151.80069841400	66.18421448290

148	-151.88142355700	66.19484643290
151	-151.86579403300	66.19663481900
152	-151.74180589500	66.17875755260
153	-151.85495315600	66.19275046130
156	-152.06763200600	66.21217227650
157	-152.06132468000	66.21471947230
158	-152.05445733700	66.21122337810
162	-151.73714176700	66.18259458590
167	-151.84635654900	66.19204775640
170	-151.77859618600	66.18646812550
171	-151.84279914300	66.18885403360
175	-151.83616209100	66.19291290520
181	-151.76927453400	66.18840931980
182	-151.79973131300	66.18851082380
183	-152.09384435700	66.21387552470
184	-152.07992700100	66.21057575640
185	-152.06662477600	66.21384260690
186	-152.06292073700	66.21305509320
187	-152.05132523000	66.21249398660
188	-152.03947579200	66.20992298540
189	-152.04655960600	66.20602747190
190	-152.04075976800	66.20108928430
193	-152.01666728200	66.20352503590
198	-151.98163424400	66.20986651650
199	-151.97433211500	66.20692389350
200	-151.96824747500	66.20327645470
204	-151.94590729500	66.19451459500
206	-151.77614893400	66.18815125310
222	-151.85068343400	66.19289791260
225	-151.77846770500	66.18803789800
226	-151.82559144100	66.18957312910
229	-151.82439962200	66.19242033590
231	-151.84260621400	66.19060176070
234	-151.80509327000	66.18426698810